

MAY 18 1982

1082

Y3.T25:2 K41

Preliminary Assessment
of the
Potential for a
Resource Recovery Project in
Christian County, Kentucky

ORIGINAL

COMPLETED
47

Technical Assistance
Provided by
Tennessee Valley Authority

December 1981

TVA/OP/EDT-82/11

ASSESSMENT FOR POTENTIAL RESOURCE
RECOVERY PROJECT
IN CHRISTIAN COUNTY, KENTUCKY

Technical Assistance
provided by
Tennessee Valley Authority

December 1981

DISCLAIMER

This report was prepared by the Division of Energy Demonstrations and Technology of the Tennessee Valley Authority (TVA). Neither TVA nor any of its agents or employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

PROLOGUE

The passage of Public Law 94-580, known as the Resource Recovery and Conservation Act of 1976 (RCRA), has placed a tremendous burden on the communities of the United States to identify and implement systems for solid waste management whereby urban and industrial waste can be disposed of in an environmentally acceptable manner. This law, coupled with the national energy crisis, makes it imperative that solid waste be used as a source of materials and energy. Estimates have indicated that over 130 million tons of municipal waste, containing an energy equivalent of over 208 million barrels of crude oil, are generated in the United States each year. Through concentrated efforts to recover energy from waste materials, utilization of these waste resources could result in a reduction in the Nation's dependency on oil.

During recent years attention has been directed toward recovery of energy from solid waste as a means of supplementing dwindling energy supplies and providing alternative disposal methods. In the Tennessee Valley region a need exists for developing, demonstrating, and evaluating alternative disposal methods that meet community needs for solid waste disposal and that are compatible with national goals of resource conservation and environmental protection. Renewed emphasis on energy conservation and recent legislation regarding land disposal of solid waste has focused attention on resource recovery systems as viable and timely alternative methods.

TVA's early involvement with the region's solid waste problems was directed toward filling the broad technological void that existed in the solid waste management field, increasing the capacity of local governments to provide basic services, and marshalling local efforts into a unified

resource development effort. TVA's technical expertise was made available to assist local governments in closing illegal dumps and in developing sanitary landfills and rural bulk container collection systems.

In July 1976, the Tennessee Valley Authority completed a study entitled Study of the Feasibility of a Regional Solid Waste Derived Fuel System in the Tennessee Valley Authority Service Area. This study addressed the feasibility of developing a regional solid waste energy and resource recovery system which would provide solid waste derived fuel for selected existing coal-fired electric generating plants operated by TVA. The study showed at that time negative feasibility for the concept as defined for the stated reason that the cost of collecting and transporting solid waste in the volumes necessary for use in the large TVA generating plants and the cost of retrofitting existing plant boilers to accommodate this type of fuel would be too high. TVA recognized, however, the benefits in conservation of petroleum-based fuels which might be derived through energy recovery from solid wastes on a smaller, more localized scale where the primary fuel (solid waste) would be locally generated and the recovered energy could be locally marketed in the most convenient form (steam or electricity).

As a result of this work, TVA implemented a regional waste-management program to study and assess solid waste management and resource recovery technologies and to advise interested governmental bodies in the TVA region with respect to solid waste management and energy recovery alternatives available to them. Within budget limitations, the Waste Management Staff of TVA's Energy Demonstrations and Technology Division will render planning and advisory assistance to communities in studying solid waste incineration and energy recovery to reduce the need for landfill operations

for disposal of solid waste materials in the Tennessee Valley region.

TVA will also be instrumental in demonstrating new technologies.

CONTENTS

	<u>Page</u>
Prologue	iii
Introduction	1
Solid Waste Inventory	1
Energy User Inventory	3
Assessment for Potential Project	5
Transfer Hauling	13
Exhibit A	15

TABLES

	<u>Page</u>
1. Amount of Refuse Accepted at Hopkinsville, Kentucky, Landfill	2
2. Energy User Survey	4
3. Average Daily Steam Consumption at U.S. Tobacco.	5
4. Cost Estimate for 200 TPD Modular Controlled Air Incinerator with Steam Production for Christian County, Kentucky	9
5. Life Cycle Cost Analysis - Controlled Air Incinerator System, Christial County - 100% Steam Sales	10
6. Cost Estimate for 200 TPD Modular Waterwall Incinerator with Steam Production for Christian County, Kentucky	11
7. Life Cycle Cost Analysis - Modular Waterwalled Incinerator System, Christian County - 100% Steam Sales	12

BEST DOCUMENT AVAILABLE

Introduction

The city of Hopkinsville, Kentucky, operates a landfill located on a 220-acre site on the outskirts of the city. This is the only landfill serving Christian County, and the communities surrounding Christian County have expressed a possible need to utilize this landfill in the near future. The life expectancy of the landfill is estimated to be several years; but due to the increasing size of the wasteload, local officials were prompted to request technical assistance from the Tennessee Valley Authority in the form of a solid waste management/resource recovery feasibility study.

After initial meetings between Hopkinsville officials and TVA personnel, it was decided that a preliminary assessment of the potential for resource recovery in Christian County should commence in the spring of 1981. This study would offer possible alternatives to landfilling by describing various ways in which municipal solid waste could become a viable fuel source for local industry. Included in the study would be a description of the present solid waste management operations, an outline of any options available in the area of resource recovery, and cost estimates for waste management alternatives.

Solid Waste Inventory

Field work for this study was begun in June 1981. At the time accurate solid waste data was not available; however, permanent scales were being installed at the landfill to weigh incoming refuse trucks. A weighing program was initiated during the month of August and ran three and one-half weeks.

Table 1 lists the daily tonnages which were tabulated August 3 through August 26, 1981. The average daily amount of solid waste delivered to the

Table 1

AMOUNT OF REFUSE ACCEPTED AT HOPKINSVILLE, KENTUCKY, LANDFILL

Date	Pounds	Tons
August 3, Monday	401,740	200.17
4, Tuesday	340,670	170.34
5, Wednesday	356,700	178.35
6, Thursday	280,590	140.30
7, Friday	228,400	114.20
10, Monday	445,920	222.96
11, Tuesday	288,110	144.06
12, Wednesday	285,270	142.64
13, Thursday	346,714	173.36
14, Friday	244,290	122.15
17, Monday	417,643	208.82
18, Tuesday	317,440	158.98
19, Wednesday	283,960	141.98
20, Thursday	282,060	141.03
21, Friday	324,970	162.49
24, Monday	414,742	207.37
25, Tuesday	302,513	151.26
26, Wednesday	292,940	146.47

landfill (five days a week) is 163 tons. Therefore, 815 tons are delivered weekly; 3,532 tons monthly; or 42,380 tons annually. A dumping fee of \$5/ton is charged to those persons hauling waste to the landfill.

The population of Christian County is 66,878, which is expected to increase to 80,800 by 1990.* Based on the present waste load of 42,380 tons per year, by 1990 this amount should increase to 56,700 tons per year.

Energy User Inventory

An inventory of prospective energy customers was taken in Christian County. TVA representatives visited various industrial to collect data concerning steam usage for plant processing, hot water heating, and space heating. Table 2 lists those industries which were contacted and shows information received from each.

The results of the survey indicate that there are several steam users in Christian County with some process steam requirements, space heating, and hot water needs. But after close analyses of these industries' actual steam requirements on an hourly basis, it was discovered that none of the steam demand rates were of the necessary magnitude upon which a resource recovery project could be based. In order to maintain a resource recovery system in a cost-effective manner, it is imperative that a large percentage of the available steam be marketed on a continuing basis.

*1980 Census Population. Projections of Economic Activity in Kentucky, U.S. Bureau of Economic Analysis.

Table 2
ENERGY USER SURVEY

Industry	Steam Use	Steam Pressure (psi)	Steam Demand Schedule
Phelps Dodge	Space heating	30-40	6180 lb/hr winter; 4120 lb/hr summer; 24 hr/day
Thomas Ind.	Space heating	80	8800 lb/hr; 8 hr/day; 5 day/wk
	Processing		1600 lb/hr; 12 hr/day; 7 day/wk
Ebonite	Space heating	100	8280 lb/hr winter; 24 hr/day;
	Processing		8280 lb/hr summer; 10 hr/day;
U.S. Tobacco	Space heating	125	6800-21,000 Jan-May; 16 hr/day
	Processing		14,000 June-Dec; 8 hr/day
Superior Graphite	None		
Phillips Products	None		
Mid-Continent Spring Company	None		
International Shoe Company	None		
Pellon	None		
Plymouth Tube Co. Wire Plant	None		
Embart Bailey	None		

Assessment for Potential Project

Approximately 42,000 tons of waste are delivered to the Hopkinsville landfill annually. Should the need arise for additional communities to utilize the city's landfill (e.g., +250 tons per week from Hopkins County), this amount could increase to 55,000 tons annually. If this waste were processed in a resource recovery facility on a continuous operating schedule, anywhere from 24,000 to 40,000 pounds of steam per hour could be produced and sold depending upon the type of waste processing technology selected.*

As seen in Table 2, the industry with the greatest steam demand in Christian County is U.S. Tobacco, which operates one plant year-round and another plant five months out of the year. The average daily steam demand based on monthly fuel (propane) consumption rates is listed in Table 3.

Table 3
AVERAGE DAILY STEAM CONSUMPTION AT U.S. TOBACCO

Month	lb/day
January	214,353
February	192,673
March	148,806
April	72,974
May	78,187
June-December	52,730

Based on the amounts of waste presently collected in Christian County (163 tpd, 5 days per week), approximately 582,000-734,000 pounds of steam per day would be available for marketing. If this amount should increase to 213 tpd, 5 days per week, then 761,000-958,000 pounds of steam would be available.

*5000 lb steam/ton of waste modular controlled air system.
6300 lb steam/ton of waste modular waterwalled system.

The greatest steam demand at U.S. Tobacco is seen in January. This steam demand equals approximately 37 percent of the minimum amount of steam which would be available from the present waste load and a much lower percentage should the waste load increase. As has already been stated, it is imperative that a large percentage of the steam produced at a waste processing facility be sold to a steam customer in order for the project economics to be cost-effective. Even with a combination of the steam users located in Hopkinsville/Christian County, the necessary steam demand is not great enough to provide the revenue needed for a feasible project. However, if a new industry should locate in Hopkinsville, which has a steam demand great enough to utilize either most of the available steam or make up the difference between the present use rates and the amount of steam available from a waste processing facility, then the prospects for a feasible resource recovery project would become much greater. Also, if surrounding counties should consider resource recovery as an alternative to landfilling, and an energy survey should reveal an available steam market great enough to utilize most or all of the steam produced from solid waste from one or more counties, then a regional or multi-county approach could be taken if future evaluations are to be made for this area.

A system capable of processing 200 tons of waste per day would be adequate for handling waste delivered to Christian County through the 1990's based on present waste loads and collection practices, as well as future projected waste quantities.

All solid waste delivered to a resource recovery facility would be handled inside and out of view of adjacent property owners. Incoming refuse trucks are unloaded directly onto a tipping floor or into a storage pit which can hold a minimum of three days' supply of waste.

BEST DOCUMENT AVAILABLE

Rubber-wheeled front loaders or a crane then transfers the waste from the storage area into the combustion units. Odor is not usually a problem because combustion air is drawn from the waste storage area so that the odor is destroyed when it passes through the incinerator.

The combustor process does not require auxiliary fuel except for unit startup load following and, in some systems, for pollution control. The solid waste is reduced in volume by about 90 percent and in weight by about 75 percent. The hot gases resulting from the combustion gases are cooled by the heat exchangers and then cleaned by the air pollution control system to meet Federal and State air quality control criteria. By the time the gases exit the stack, no visible soot or smoke is present. A conceptual drawing of a typical solid waste heat recovery facility is shown in Exhibit A.

A backup landfill must be maintained so as to allow for disposal of system residues (about 10 percent of original volume; 25 percent of original weight) plus occasional disposal of raw waste when there is a plant outage.

The cogeneration of electricity could also be an added option to Christian County's resource recovery project, extending the utilization of municipal solid waste as a fuel source. Approximately 5,000 to 6,300 pounds of steam can be produced from one ton of solid waste; and with the addition of a turbogenerator to the recovery facility, this steam can also produce electricity. The amount of electricity produced is dependent upon the type of turbine used in the system and the steam conditions required by the steam users. Assuming that high-pressure steam is manufactured from this area's solid waste, a backpressure turbine could then produce electricity. The exit low-pressure steam would be sold to industrial customers.

Cost estimates done for this assessment are based upon a hypothetical situation in which a steam customer who could utilize 100 percent of the available steam is located in the Hopkinsville area. Two types of waste processing technologies are included. The first computation is for the modular controlled-air system and the second is for the more expensive modular waterwalled system. The waterwalled energy recovery system is the most appropriate technology for producing high-pressure steam to be used with a turbogenerator for electrical cogeneration. Though it is more expensive, it is more thermal efficient and the added revenues can serve to offset the costs. However, the practicality of the addition of electrical cogeneration to the resource recovery project should be evaluated when and if appropriate steam users are identified. The future process steam parameters (lbs/hour, psi) will determine the suitability of one system over another which in turn determines the feasibility of the added option (electrical cogeneration) to the basic project.

Table 4 gives the capital, owning, and operating costs for a resource recovery facility using the modular controlled air technology. Table 5 lists the life cycle cost analysis (15 years) for a system of this type based on a 100 percent steam market beginning in 1984 with the corresponding projected waste load. Tables 6 and 7 list the same cost computations for the modular waterwalled system. Life cycle costs are geared to a 20-year period. See Exhibit A for a detailed description of incineration-waste heat recovery systems.

Table 4

COST ESTIMATE FOR 200 TPD MODULAR CONTROLLED
AIR INCINERATOR WITH STEAM PRODUCTION FOR
CHRISTIAN COUNTY, KENTUCKY

1984 Tonnage - 55,000

I. Project Cost

A. Site Development	\$ 700,000
B. Land	100,000
C. Plant Building	1,100,000
D. Incinerator/Boiler/Pollution Control & Auxiliaries, Installed	6,600,000
E. Distribution System (Assume 1000')	220,000
F. Engineering; Administration; Startup; Testing	550,000
G. Bond Financing Expense	396,000
H. Construction Interest Less Investment Earnings	880,000
I. Contingency	1,000,000
J. Bond Reserve Fund	<u>3,126,000</u>
TOTAL BOND ISSUE	\$14,672,000

II. Annual Project Costs

A. Annual Owning Cost (15 yrs. @ 12%; CRF = .1468)	\$2,154,000
B. Operating and Maintenance Costs	
1. Personnel	\$380,000
2. Water & Chemical	48,000
3. Auxiliary Fuel	70,000
4. General & Administrative	74,000
5. Utilities	100,000
6. Ash Disposal	50,000
7. Maintenance	<u>250,000</u>
SUBTOTAL	<u>972,000</u>
TOTAL ANNUAL PROJECT COST	\$3,126,000

BEST DOCUMENT AVAILABLE

Table 5
LIFE CYCLE COST ANALYSIS - CONTROLLED AIR
INCINERATOR SYSTEM
CHRISTIAN COUNTY - 100% STEAM SALES

	1984	1989	1994	1998
A. Annual Tonnage (.5% annual increase)	55,000	56,389	59,813	58,978
B. Annual Owning Cost	\$2,154,000	\$2,154,000	\$ 2,154,000	\$ 2,154,000
C. Annual Operating Cost (escalated at 8%)	\$ 972,000	\$1,428,000	\$ 2,098,000	\$ 2,855,000
D. Total Annual Cost	\$3,126,000	\$3,582,000	\$ 4,252,000	\$ 5,009,000
E. Annual Steam Sales (10 ³ lbs)	247,500	25,375	260,157	265,399
F. Annual Steam Revenues*	\$2,160,000	\$3,913,000	\$ 7,070,000	\$11,349,000
G. Interest on Bond Reserve**	\$ 375,000	\$ 375,000	\$ 375,000	\$ 375,000
H. Net Cost (Profit)	\$ 585,255	\$ (705,877)	\$(3,192,721)	\$(6,715,242)
I. Net Cost (Profit) per Ton of Waste	\$ 10.64	\$ (12.52)	\$ (55.23)	\$ (113.86)

*Assumes \$8.75/1,000 lbs steam in 1984, and 12 percent annual increase after 1984.

**Assumes 12 percent interest rate.

Table 6

COST ESTIMATE FOR 200 TPD MODULAR WATERWALL
INCINERATOR WITH STEAM PRODUCTION FOR
CHRISTIAN COUNTY, KENTUCKY

1984 Tonnage - 55,000

I. Project Cost

A. Site Development	\$ 750,000
B. Land	100,000
C. Plant Building	1,000,000
D. Incinerator/Boiler/Pollution Control & Auxiliaries, Installed	7,500,000
E. Distribution System (Assume 1000')	220,000
F. Engineering; Administration; Startup; Testing	750,000
G. Bond Financing Expense	500,000
H. Construction Interest Less Investment Earnings	1,000,000
I. Contingency	1,500,000
J. Bond Reserve Fund	<u>3,168,000</u>
TOTAL BOND ISSUE	\$16,488,000

II. Annual Project Costs

A. Annual Owning Cost (20 yrs. @ 12%; CRF = .1339)	\$2,208,000
B. Operating and Maintenance Costs	
1. Personnel	\$380,000
2. Water & Chemical	48,000
3. Auxiliary Fuel	40,000
4. General & Administrative	80,000
5. Utilities	112,000
6. Ash Disposal	50,000
7. Maintenance	<u>250,000</u>
SUBTOTAL	<u>960,000</u>
TOTAL ANNUAL PROJECT COST	\$3,168,000

Table 7

LIFE CYCLE COST ANALYSIS - MODULAR WATERWALLED
INCINERATOR SYSTEM

CHRISTIAN COUNTY - 100% STEAM SALES

	1984	1989	1994	1999	2003
A. Annual Tonnage (.5% annual increase)	55,000	56,389	57,813	59,273	60,467
B. Annual Owning Cost	\$3,179,000	\$ 3,179,000	\$ 3,179,000	\$ 3,179,000	\$ 3,179,000
C. Annual Operating Cost (escalated at 8%)	\$ 960,000	\$ 1,411,000	\$ 2,073,000	\$ 3,045,000	\$ 4,143,000
D. Total Annual Cost	\$4,139,000	\$ 4,590,000	\$ 5,252,000	\$ 6,224,000	\$ 7,322,000
E. Annual Steam Sales (10 ³ lbs)	311,850	319,725	327,798	336,075	342,847
F. Annual Steam Revenues*	\$2,729,000	\$ 4,930,000	\$ 8,908,000	\$ 16,096,000	\$ 25,838,000
G. Interest on Bond Reserve**	\$ 497,000	\$ 497,000	\$ 497,000	\$ 497,000	\$ 497,000
H. Net Cost (Profit)	\$ (58,000)	\$(1,807,000)	\$(5,125,000)	\$(11,340,000)	\$(19,983,000)
I. Net Cost (Profit) per Ton of Waste	\$ (1.05)	\$ (32.08)	\$ (88.65)	\$ (191.31)	\$ (330.47)

*Assumes \$8.75/1,000 lbs steam in 1984, and 12 percent annual increase after 1984.

**Assumes 12 percent interest rate.

Transfer Hauling

In the event that adjoining counties decide to haul waste to a resource recovery facility in Christian County, constructing a transfer station may have to be considered should hauling distances exceed 15 miles. The overall purpose for a transfer station is to reduce the handling and transportation costs associated with the collection and disposal of solid waste.

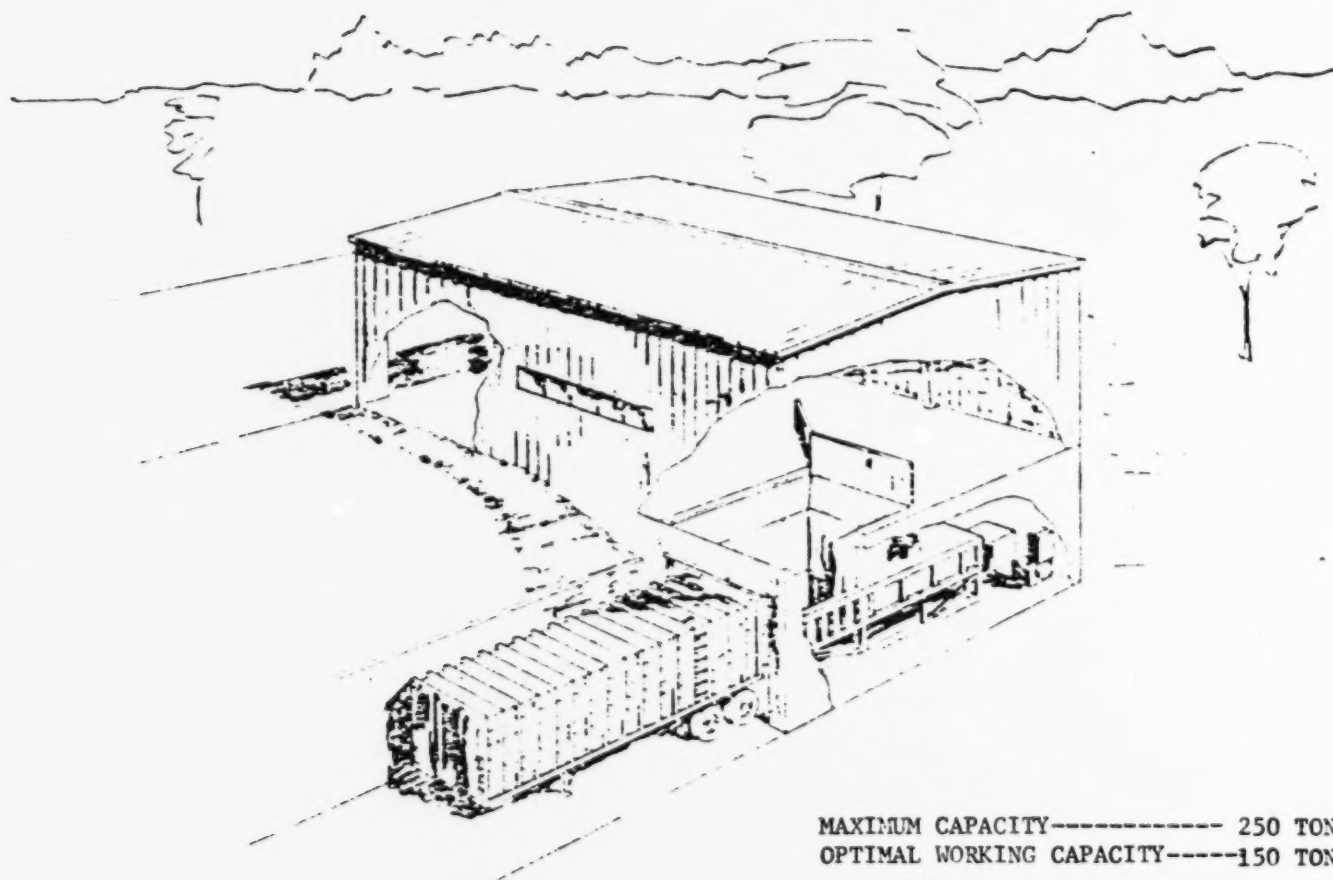
A conceptual drawing of a typical 1-packer transfer station is shown in Figure 1. Basically, the facility packs waste from smaller trucks into larger transfer trailers that are able to haul waste more economically over long distances. One transfer trailer can hold 65 to 70 cubic yards of waste or about 20 ton, which is equivalent to 3 to 5 collection trucks.

A typical transfer station consists of a bilevel building, a stationary packing mechanism with a hopper, and the necessary number of trailers and trucks. Incoming local collection vehicles discharge their waste directly onto the tipping floor or into the packer hopper. The packer pushes the waste into the transfer trailer and compacts it to the desired volume. When full, the trailer is disconnected from the packer hopper and hauled to the disposal facility. At the disposal facility, the waste is unloaded from the trailer with a self-contained ejection system.

Whenever it is necessary for the local collection vehicles to discharge the waste onto the tipping floor rather than into the hopper, a small rubber-wheeled loader will be required to push the waste into the hopper.

Under normal conditions, the transfer station can be operated by one semiskilled laborer. The transfer trucks will obviously require experienced over-the-road truck operators.

BEST DOCUMENT AVAILABLE



Typical One Packer Transfer Station

EXHIBIT A

BEST DOCUMENT AVAILABLE

ENERGY AND RESOURCE RECOVERY TECHNOLOGY ALTERNATIVES

INCINERATION-WASTE HEAT RECOVERY SYSTEMS

Incineration is the process of thermal combustion which reduces the volume of solid waste while producing inoffensive gases and ash by the application of the combustion process. Municipal incinerators are designed for self-sustained combustion of municipal solid waste under controlled conditions that maximize volume reduction while minimizing the emission of pollutants.

Incineration systems, once considered an important advance in sanitary refuse disposal and then criticized as an air and water polluter, are now undergoing intensive technical development to meet new, high standards of air and water pollution control. While technology development of incineration systems continues, the public at large has tended to mistrust this method of solid waste disposal. However, current fossil fuel shortages and the recognition of the energy value potential of municipal refuse has created an interest in these advanced systems of incineration which incorporate heat or energy recovery systems.

An incineration system operating at temperatures of 1300° to 2000° Fahrenheit, and at a loading rate that allows time for complete combustion, can convert municipal refuse to an inorganic residue containing metal, glass, and ash. With proper cleaning and filtering of stack exhaust, air pollution would be almost nonexistent; and with added attention to the aesthetics of exterior design and landscaping, public acceptance could be assured.

BEST DOCUMENT AVAILABLE

Modular Controlled Air Incinerators

The design of some municipal incinerators is based on the controlled air combustion principles. Two refractory-lined and insulated chambers, designated primary and secondary, are used for the combustion process; and a refractory-lined stack is used to duct the exhaust gases to the atmosphere. Controlled air incinerators were first commercially available in the United States during the early 1960's. However, substantial acceptance of their concept was not reflected in the marketplace until the late 1960's or early 1970's.

The controlled air system employs two chambers to accomplish the incineration process. The lower chamber is designated as the primary chamber, and the upper chamber as the secondary chamber. In the front of each primary chamber is a hydraulic ram feeder where the unsorted municipal solid waste is deposited and metered into the primary chamber. Ignition takes place in the primary chamber. Once preset conditions of temperature and time have been achieved, the primary chamber auxiliary fuel burners turn off automatically and the combustion system is self-sustaining.

These systems were developed to minimize particulate emission on incineration equipment. In order for these units to perform in a nonpolluting mode, the conditions in the two chambers must be controlled. A reducing atmosphere (insufficient oxygen for complete combustion) is maintained in the primary chamber, and the gas velocities are kept very low to minimize the entrainment of particulates in the effluent gas stream. This system is sometimes called "starved air" incineration since the lower chamber's operating characteristics provide for a partial pyrolysis system.

The heat release in the lower chamber is controlled by limiting the introduction of combustion air to an amount which provides for partial oxidation of the waste in the chamber. The heat release is sufficient to provide self-sustained partial oxidation reactions. The gas velocity in the lower chamber is influenced by several factors. The gas, which evolves from this chamber, is a result of the interaction of the air, the auxiliary fuel, and the oxidation and volatilization products from the waste. The quantity of gas from the waste can vary substantially depending upon the chamber conditions and the waste; as a result, the lower chamber velocity could be significantly altered. The waste is moved through the primary chamber either by stepped transfer rams, by drag chains, or by the injection of additional waste material pushing the already burning waste further to the rear of the unit.

The effluent gas stream from the lower chamber is introduced into the secondary chamber through a zone of turbulent air flow where ignition takes place and the combustion process is completed. The primary function of the secondary chamber is to complete the oxidation reaction of the combustible products as they are received from the lower chamber. In order to accomplish this, conditions in the chamber must be controlled within rather narrow bands from inputs, which vary widely. This is accomplished by maintaining an oxidizing atmosphere (excess air) and by modulating both air and auxiliary fuel in the secondary chamber. The interjection of auxiliary fuel and maintaining retention time in the secondary chamber will ensure complete oxidation of the combustible material in the gas stream.

It is important that the temperatures in the upper chamber are maintained at less than 2500°F in order to minimize nitrogen oxide production

BEST DOCUMENT AVAILABLE

to ensure equipment durability and of at least 1800°F in order to stabilize an adequate reaction rate to complete the combustion process. The primary means of controlling the temperatures in the secondary chamber are to add auxiliary fuel when the temperatures drop below a minimum level and to add air when the temperatures rise above the maximum level.

Controlling the air flows in the upper and lower chamber is extremely important in order to minimize the peaking activity and to provide a uniform flow of gas. This is important for controlling pollution performance as well as efficient energy recovery.

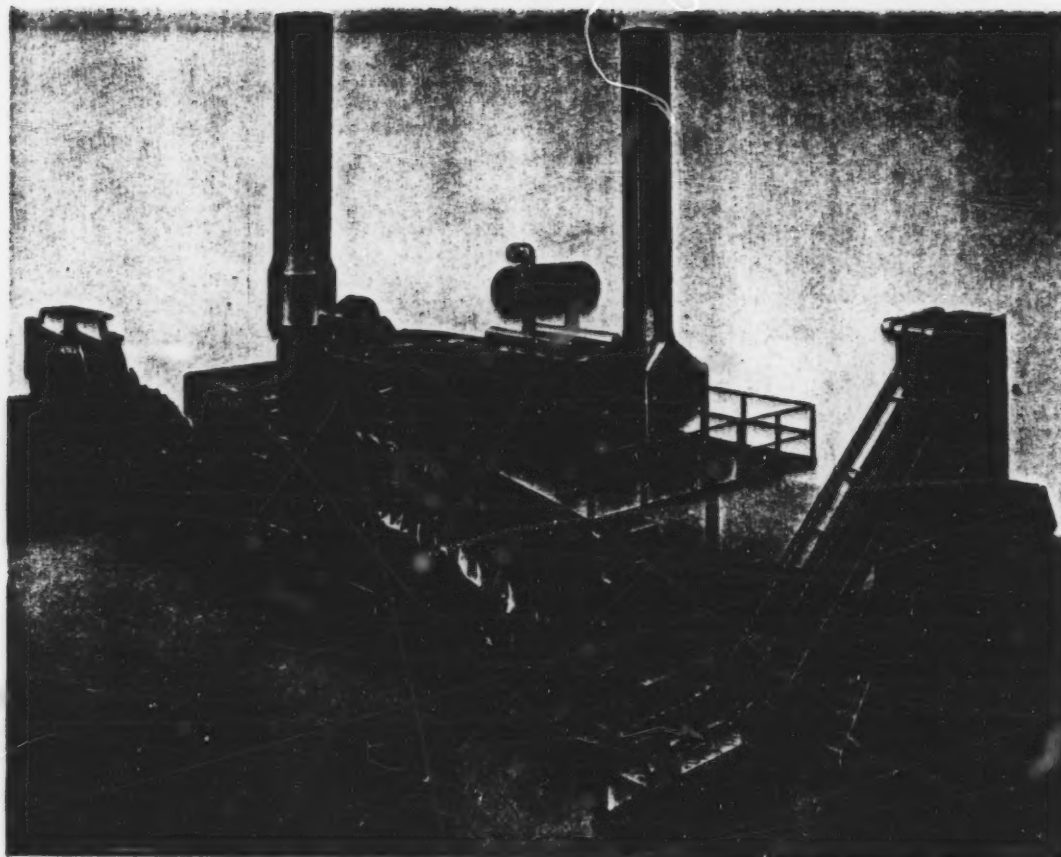
The noncombustible portion of the waste and the carbonous residue from the reaction remain in the lower chamber. The noncombustibles are rendered sterile by the relatively high temperatures, while the carbonous material is further oxidized by incoming air.

To achieve continuous operation, the systems are equipped with automatic ash removal. The ash is removed continuously from the primary combustion chamber and deposited in a quenching tank where dragout conveyors remove the cooled ashes and discharge them into a receptacle for transportation to the landfill.

Incineration modules are available for municipal systems in sizes of 25 tons per day to 100 tons per day. A number of units can be placed in the same facility to produce systems of up to 400 tons per day.

To incorporate energy recovery, waste heat recovery boilers of either a fire tube design or water tube design are utilized. Exhaust gases from the controlled air combustion modular units are drawn through the waste heat recovery boilers by an induction draft fan. Systems that employ heat recovery modules operate as described above, except that the exit gas temperatures from the secondary chamber are not allowed to exceed 1800°F.

BEST DOCUMENT AVAILABLE



Modular Controlled-Air Incinerator

19a

Modular Refractory Incinerators

The designs of some municipal incinerators incorporate the use of modular refractory combustion furnaces that consist of a refractory-lined primary chamber and a refractory-lined secondary chamber (Figure 1).

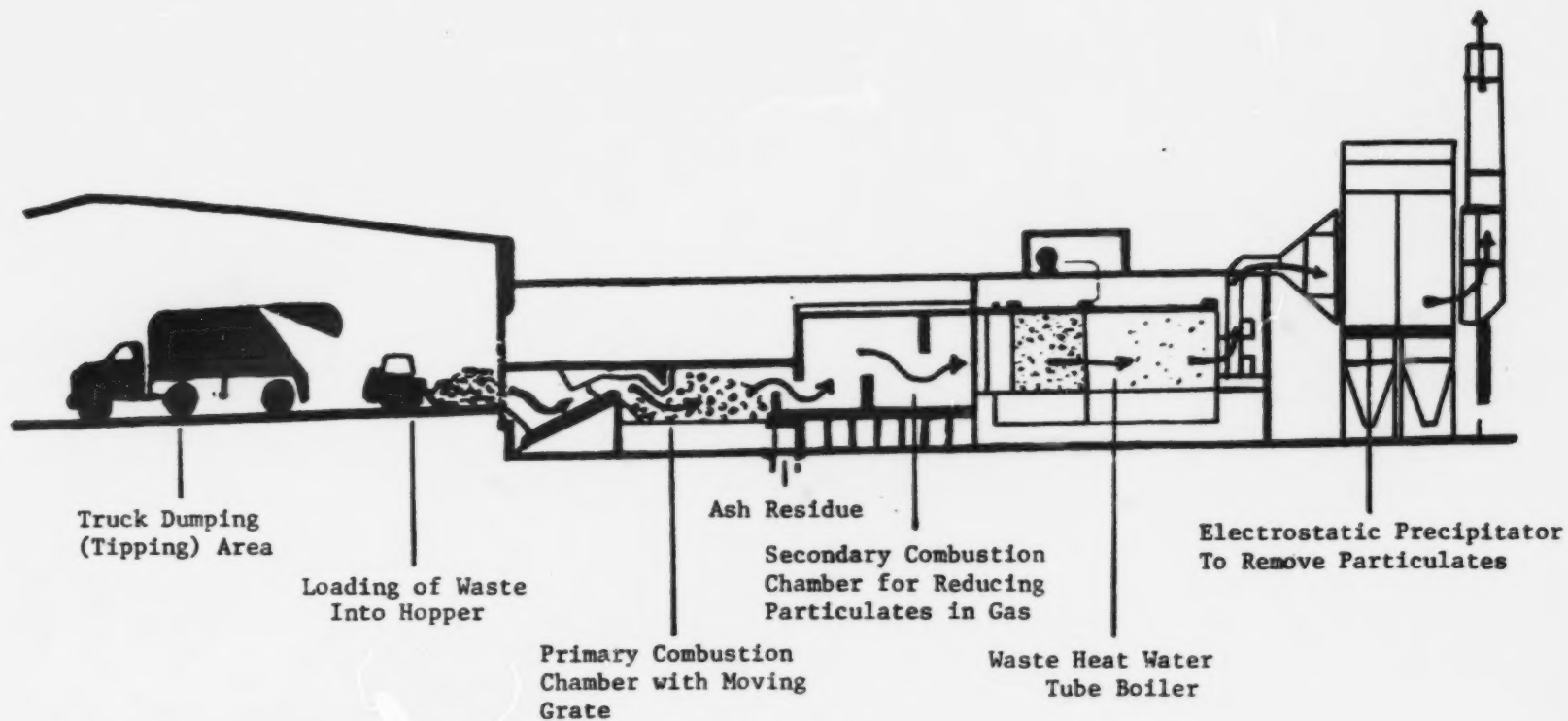
The front of each modular combustion cell consists of a gravity feed hopper. The unsorted municipal solid waste is deposited in the hopper and is metered into the furnace by means of a refuse feed conveyor. The waste is then deposited on a moving grate. The grate is sloped downward, and the entire grate reciprocates forward and backward in alternating sections. The frequency of reciprocation is varied to permit a net forward speed of 0 to 5 feet per minute with a completely loaded grate. Material is advanced on the grate as it moves backward against the bulk of the charged material and the back plate. Residence time in the furnace is maintained to allow volume reductions of about 90 to 95 percent. The individual sections of the grate have holes uniformly spaced to permit adequate distribution of underfire combustion air.

Underfire air fans supply combustion air to the furnace. The fans are equipped with variable inlet dampers to regulate the amount of underfire air. The induced draft fans produce a negative pressure in the unit, and pressure sensors located in the unit provide modulating air control.

The combustion air is pulled from the refuse storage area through the modular combustion cell, thus eliminating odors and controlling dust in the facility.

Overfire air is supplied to aid in the control and combustion of suspended particulate matter.

The design of the grate system, combined with the underfire air system, provides ideal combustion atmosphere and retention time to maximize



Modular Refractory Incinerator - Boiler System

the release of volatile and fixed carbon in the municipal refuse. The negative pressure furnace atmosphere, through the use of excess air and hot refractory, provides a controlled temperature zone. The resultant ash is primarily made up of glass, ceramic, stone, and metals. The ash residue drops from the end of the grate into a water quenching tank where a dragout conveyor removes the ash and deposits it in a container for transportation to the landfill.

Temperature control is achieved by regulating the amount of heat retained in the furnace. By opening the dampers between the furnace and the induced draft fan, less gas is pulled through the furnace; this, in turn, increases the temperature within the furnace. By closing the dampers, the induced draft fan can be used to draw gaseous products of combustion through the furnace, thus decreasing the temperature within the furnace.

Air is directed along the walls of the furnace to maintain the wall temperatures below ash fusion temperature, thus eliminating ash slag accumulation on the furnace walls. To prevent clinker formation (slagging) and clinker adhesion to the grates, close control of the furnace temperature is maintained. The design of the grate and the large volumes of air that pass through the grates keep the fuel bed temperatures next to the grates below the slag melting point.

The gaseous products of combustion pass from the primary combustion chamber over a bridge wall and under a drop arch into a secondary combustion chamber. This chamber provides the proper turbulence and retention time to ensure complete particulate burnout without the use of auxiliary fuel. Gas velocities in the secondary chamber are reduced prior to leaving to allow particulate settling before the gases pass to the waste heat recovery boiler.

BLANK PAGE

Gases leaving the secondary combustion chamber pass through a waste heat boiler that absorbs a large portion of the heat from the gas stream. The waste heat boiler also serves the purpose of preconditioning and cooling the gases to ensure against air pollution.

The exiting gases from the boiler pass through an air pollution device that is designed to ensure compliance with all existing State and Federal emission standards. The air pollution device removes the submicron particulate in the gases, and then the gases exit through a stack to the atmosphere.

A bypass arrangement is provided to allow the combustion of refuse if the boiler should be inoperable. Within the bypass is a refractory column scrubber in which the gas stream passes through a sheet of water emanating from a slot in the roof that extends across the full width of the chamber. At the end of the scrubbing section, the gas stream is deflected by a bank of tubes through a drying arch and passes through the induced draft fan; the gas stream then passes through the air pollution control device and exits through a stack to the atmosphere.

The fly ash from the air pollution equipment is conveyed to a settling basin, which is part of a clarifier tank where all water in the system flows. A dragout conveyor removes the fly ash material from the clarifier and deposits it in an appropriate container for transportation to the landfill. This enclosed circulating water system ensures that no water pollution is incurred.

The incineration modules are available in sizes from 25 tons per day up to 200 tons per day. Various combinations can provide systems up to 800 tons per day.

Rotary Waterwall Combustor-Boiler

The rotary waterwall combustor combines the technology of a rotary kiln-type furnace with that of a waterwall furnace. The unit is basically a rotary kiln with a watertube wall instead of the refractory wall normally used in the rotary kiln. The rotary combustor is a hollow cylinder made up of alternately joining steel tubes and steel plates with a number of pinholes. Each end of the boiler tubes is connected to ring headers. The cylinder is supported in a 6° inclined position by rollers and turns slowly (1/6 rpm) by a driving unit.

The waste is fed from the upper end of the rotary combustor and is slowly and continuously overturned and stirred by the rotation, while combustion air heated through an air preheater is supplied through the pinholes in the rotary combustor wall. The air is supplied evenly throughout the rotary combustor in order to facilitate the drying and the incineration of the waste. The waste is discharged from the end of the combustor onto a grate at the base of a waterwall boiler. Additional retention time is obtained on the grate before the ash is deposited into a quenching system. In order to provide optimum air distribution, a separate wind box is provided around the bottom of the combustor.

Boiler water is circulated inside the tubes which constitute the rotary combustor wall by a forced circulation system in order to protect the wall from the influence of high temperature and to recover the energy in the form of steam. The circulation water is fed to the rotary combustor from the water drum of the boiler through a rotary joint and is returned to the steam drum.

Waterwall Incineration-Unprocessed Waste

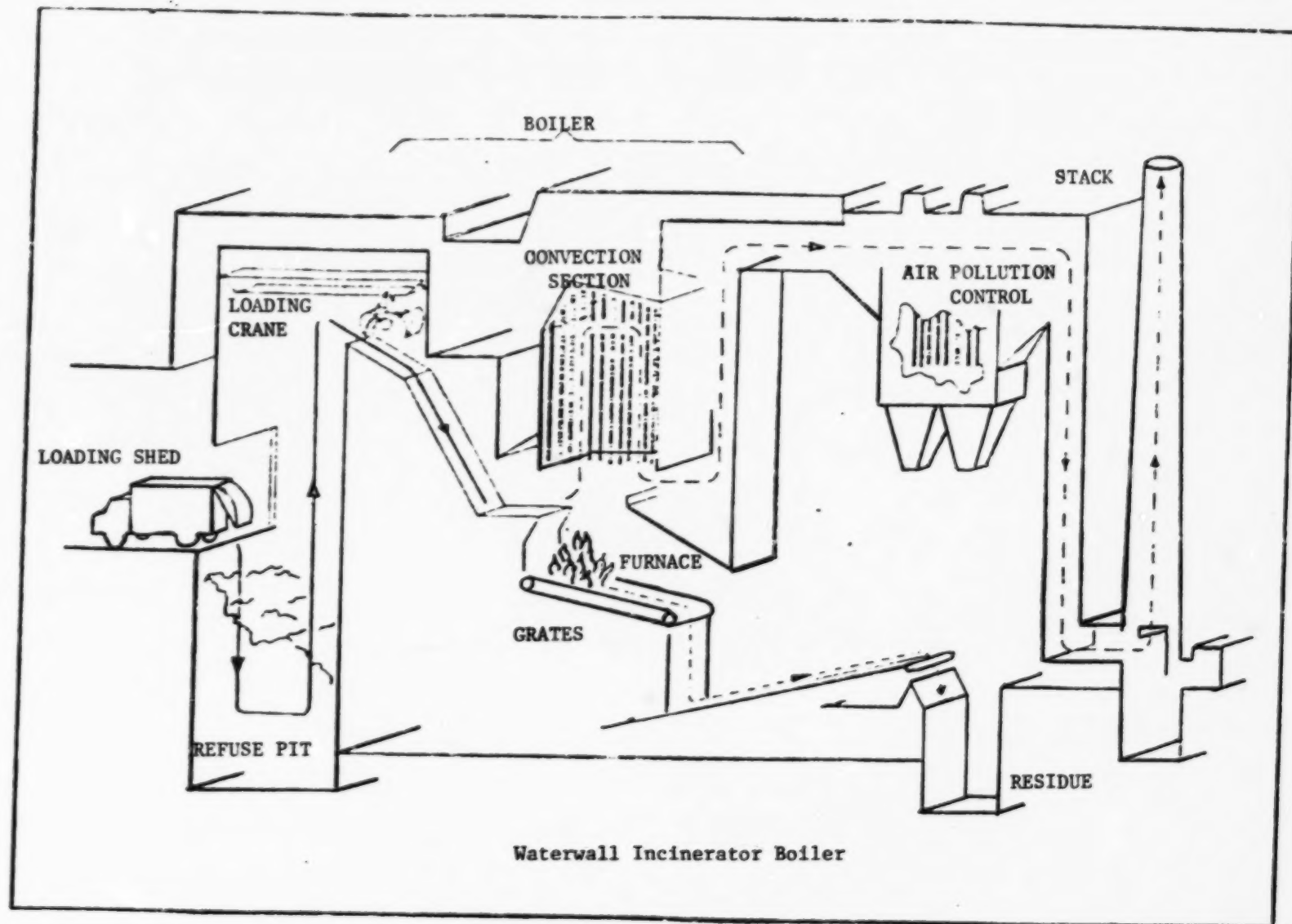
This technology was developed more than 50 years ago for use with low grade coal and other types of waste fuels, but it has only been used for municipal solid waste for about 20 years. However, in Europe and Japan, its acceptance has been rapid and widespread; and several hundred units have been built in sizes ranging from 60 to 2,600 tons per day.

Municipal solid waste is deposited on a tipping floor or in a large storage pit from which it is transferred to the furnace feed hopper. From the feed hopper, the waste is fed into the furnace where it burns as it moves continuously through the furnace. The combustion residue falls off the end of the grate where it is quenched with water and then conveyed to trucks for transportation to landfill.

The furnaces are enclosed by closely spaced, water filled tubes. Water circulating through the tubes recovers heat radiated from the burning waste. Integrally constructed heat recovery boilers generate steam while reducing the temperature and the volume of the exhaust gases. The additional sections of the boilers consist of various zones or tube packages referred to as heaters, economizers, reheaters, etc., depending on the function of the particular zone.

In the combustion process, oxygen (air) is required to burn the fuel and release the heat. Air is introduced into the furnace beneath the grates (underfire air) to aid in the combustion and to help keep the grates cool. Air is also introduced above the fuel bed (overfire air) to promote mixing of the gases (turbulence) and to complete the combustion in the furnace.

The combustion gases, after being cooled as they pass through the various boiler sections, are passed through air pollution control devices



(generally electrostatic precipitators) and are vented to the atmosphere through a stack. In a well designed and operated unit, more than 94 percent of the available energy can be released through the combustion process.

Environmental Aspects

There are four basic impacts to be considered in the establishment of an incineration waste heat recovery facility: atmospheric emissions, wastewater disposal, residue disposal, and local and in-plant environmental impacts.

Atmospheric emissions are produced by the combustion of municipal refuse fuel. Municipal refuse is far from being an easily characterized homogenous fuel. It varies widely depending upon the geographical, seasonal, and weather-related factors. Refuse is an inherently low sulfur fuel containing less than one tenth of the amount of sulfur found in typical low sulfur coals. Sulfur dioxide, carbon monoxide, and unburned hydrocarbons are not considered a problem in most resource recovery boiler systems due to the high flame turbulence and combustion time. Chlorine in municipal refuse is usually in the form of sodium chloride and chlorinated synthetics which may present corrosion problems from acid formation if temperatures are not strictly controlled.

Particulate matter has been the primary concern of most waste-to-energy systems. However, well designed pollution control devices can remove 99 percent plus of the particulate matter, thus minimizing the facility's impact on local air quality standards.

As part of the overall impact evaluation of a resource recovery facility, the pollutants emitted by motor vehicles associated with the delivery of refuse to the plant must be analyzed to determine the concentrations of carbon monoxide, hydrocarbons, and oxidants in the vicinity of the plant.

Water is utilized to some extent in all resource recovery facilities. The discharge of this wastewater produced by the operation of the facility should be considered in any environmental assessment study. These discharges include processing wastewaters, wash waters, and waters associated with the combustion process such as cooling towers and boiler blowdown.

The conversion of refuse to energy generally reduces the volume of municipal solid waste by 90 percent, thus increasing the life of existing landfills. The bottom ash and fly ash produced by these waste-to-energy systems has been found to contain trace elements such as beryllium, mercury, cadmium, and lead. However, the impact on local environment is presently considered minimal when the ash is disposed of in a properly designed and operated landfill.

Local and in-plant environmental impacts include: the containment of the malodorous air within the plant; maintenance of the carbon monoxide levels in the tipping area within OSHA limitations; fogging and disposition of solids produced by the operation of cooling towers; and noise associated with the operation of plant and the delivery of refuse to the facility. Most systems prevent malodorous air from escaping to the ambient by keeping the tipping area at a negative pressure and then drawing this air through the waste incineration system whereby the malodorous substances are destroyed.

Fresh ventilating air in the facility can control exhaust gases from refuse delivery trucks, while odors from combustion residue can be minimized by providing clean burnout followed by thorough quenching.

Proper engineering can also minimize noise levels at the facility incurred from both waste handling vehicles and waste processing activities.

Any equipment that creates noise disturbances above ambient levels at the property line of the facility or above OSHA standards for workers must be shielded in order to reduce these levels. The flow of waste handling vehicles to and from the facility should be designed to minimize effects on residential and other sensitive areas of the community.

MATERIALS SEPARATION AND RECOVERY

In an effort to extract the maximum revenue from solid waste as a resource, as well as to produce a more usable and flexible fuel for various types of furnaces, considerable investigation has been conducted on separating the raw refuse into its major components. Various systems have been developed for breaking up (shredding or milling) the bulk waste to extract the metals, glass, and both the light and heavy combustibles.

Presently, extensive recovery of materials from municipal solid waste is practiced only on a limited basis. Other than ferrous metals, material recovery technology can be considered in the stages of full scale "prototype."

The recovery of ferrous metals is practiced widely on municipal solid waste. The important consideration in ferrous recovery, as in the recovery of other materials, is the final preparation of a product suitable for sale to the marketplace.

Obviously, there are components in municipal solid waste streams that have a value as secondary or recyclable materials. The capital expenditure and operating expense to extract these in some sort of centralized "resource recovery" plant is only worthwhile if a net profit can be shown on the venture.

Although recovery of aluminum, other nonferrous metals, paper and glass cullet is not recommended at this time, such additional recovery should be reconsidered in the future as the experience and results of more extensive material recovery efforts become known.

In any combustion plant for municipal waste, there is some front end separation, even though it may be as simple as viewing the dumped waste and removing the appliances, bicycles, and furniture items that households have added to their trash piles.

All analyses show that the most valuable resource that can be extracted from municipal waste is energy. The burning of the combustible segment as a low grade, bulk fuel has been proven both economically and technically feasible in many plants of various designs throughout the world with the production of heat, steam, or electricity as the final product.

The most useful aspects of waste separation and size reduction are: to improve the characteristics of such fuels; to make them more homogeneous with better handling and burning characteristics; to improve fuel values and volatile release rates; and, with smaller ash residues, to handle these at the completion of combustion. The amount of effort and expense devoted to this end will differ with the type of combustion and boiler system being considered as will the rate of return on the investment.

If the efficiency of the fuel and the production of the net energy (the energy balance of the entire system) can only be improved a few percentage points by a large increase in capital and operating cost, the sophistication is not worthwhile.

Some systems have been developed where the additional capital and operating cost can be recaptured rather quickly by improving the energy output of the resultant fuel. If additionally there is a market for the other separated and recaptured materials (such as metals and glass) that will pay a substantial percentage of the operating cost, the whole approach begins to look attractive. In general, a 500 ton per day system would be required before this approach would be economically viable.

Handpicking

This step may be inserted at the beginning of a materials or energy recovery system in order to allow for inspection and low-level paper recovery. When municipal solid waste first enters the energy and resource recovery facility, old newspapers and corrugated boxes are handpicked from a conveyor belt prior to processing in the facility. In this way, a small but saleable amount of clean paper is recovered while allowing for simultaneous inspection of the waste stream from materials which could cause possible harm in the energy recovery system.

The newspaper and corrugated boxes could be fed separately into a baler in order to facilitate subsequent storage and shipment for sale.

Mechanical Separation

Mechanical separation of waste components universally follows certain basic steps, the first of which is to reduce all the waste to a predetermined size range by shredding or milling it either on a dry basis (the most common method) or by wet pulping. Shredding or milling may be on an extremely coarse basis which reduces the waste stream into large pieces of 4 to 8 inches in size, or it may be multistage that literally reduces the entire waste stream to pieces of under 1 inch in size. As the particle size decreases, more process stages and equipment are required, thus increasing the capital and operating expense.

Once the design size reduction is achieved, the waste is then moved through an air classifier. The lightweight paper and plastic, along with many combustible organics, can be lifted away from the heavier items (such as metals, glass, and heavier combustibles). As much as 60 percent of the total stream is in the form of light combustibles and can be separated out in this system.